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THE RIVER DELTAS OF THE GIPPSLAND LAKES

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Abstract

Deltaic sedimentation at the mouths of rivers flowing into the Gippsland Lakes has been influenced by the silt-trapping effects of lake-shore reed growth (chiefly *Phragmites*). The reed-fringed deltas of the Latrobe and Avon in L. Wellington continue to grow but the deltas of the Mitchell, Nicholson and Tambo in L. King are being consumed by wave erosion, following the disappearance of a former shoreline reed fringe indicated by die-back features and by historical and cartographic records. Loss of *Phragmites* is correlated with increased salinity in L. King.

Hypotheses advanced for the origin of the Mitchell 'silt jetties' are discussed in the light of evidence from the valley floor S. of Bairnsdale, where a former lake-shore beach is identified. It is concluded that this delta grew from the vicinity of Bairnsdale southwards to Eagle Point Bluff and thence eastwards into L. King.

Introduction

The Gippsland Lakes are a group of coastal lakes in E. Victoria, between 150 and 200 m. E. of Melbourne. They developed during Recent times, when the world-wide marine transgression that accompanied the reduction of the Pleistocene ice sheets submerged the lower parts of the E. Gippsland river valleys to form a broad embayment. This was subsequently cut off from the sea by the formation of a series of sandy coastal barriers bordered on the seaward side by the Ninety Mile Beach. The lakes thus enclosed include L. Wellington, L. Victoria, L. King and a number of smaller lagoons, and are fed by 5 main rivers, the Latrobe, Avon, Mitchell, Nicholson and Tambo. At Lakes Entrance they open to the sea by way of an artificial outlet cut through the coastal barriers in 1889.

These lakes have had a very complex physiographic history. Their configuration has changed as the result of erosion and deposition by waves and currents, by the encroachment of swamp land around their shores, and by the growth of deltas at the mouths of the inflowing rivers. These changes continue, and it is clear that, in terms of the geological time-scale, the Gippsland Lakes will not exist much longer; sedimentation will convert them into a depositional coastal plain, or marine erosion will destroy all trace of them.

The river deltas that protrude into the lakes are of considerable interest, and any attempt to describe their mode of origin must also account for their condition at the present time. The Latrobe and Avon are building deltas into L. Wellington, but the deltas built by the Mitchell, Nicholson and Tambo rivers in the N. part of L. King are being destroyed by wave erosion and it appears that the conditions which permitted their growth no longer exist. An enquiry into their mode of origin is best preceded by an account of the typical sequence of physiographic evolution in a submerged river valley.

When the lower reaches of a river valley are drowned by coastal submergence, river sediment is deposited in such a way that the drowned reaches become shallower, until eventually an alluvial valley-floor is developed across them. Rivers with a seasonal regime, subject to flooding at certain times, tend to build natural levees, high banks of silt bordering the river channel. The best known are those along the lower Mississippi R. (Russell 1936), which are built up by deposition from flood waters. When a river rises and overflows its banks, inundating the valley

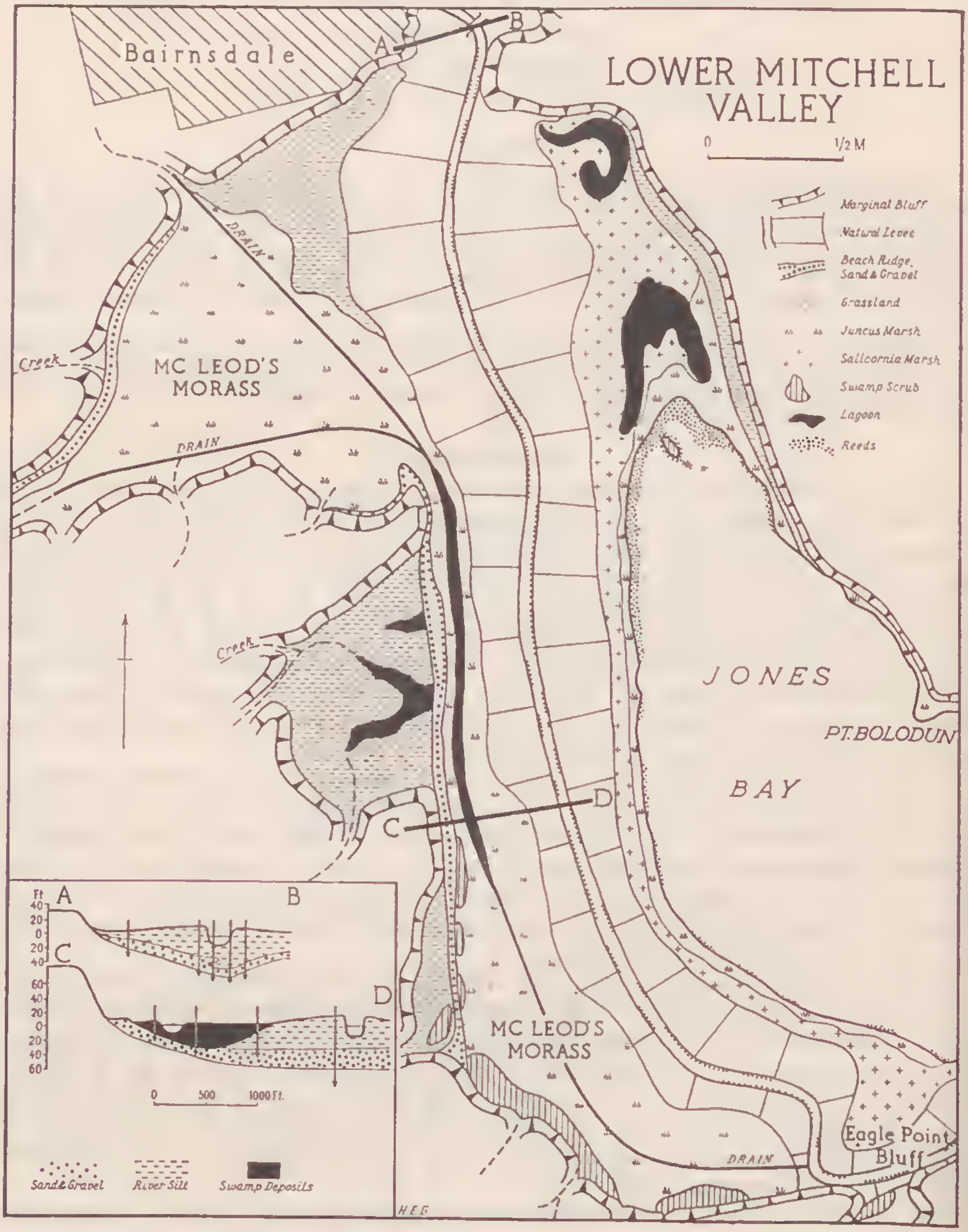

Fig. 1—The Lower Mitchell valley between Bairnsdale and Eagle Point Bluff.

floor, the flow of water is most rapid along the line of the river channel and much slower on either side. Silt carried by the floodwaters is relinquished at the borders of the channel, where the water velocity diminishes, and only the finer clay sediment is carried into the calmer water beyond. In this way a valley-floor that is being built up, or aggraded, by deposition shows a river channel bordered by natural levees which slope away into lateral depressions. In Louisiana these are known as levee-flank or backswamp depressions. Flood water may persist in them for long periods, particularly if the levees reach the valley side locally, so as to enclose depressions and prevent down-valley drainage. They are floored with clay deposited from flood waters, and very often they are occupied by fen or swamp vegetation, which may build up peat deposits.

The process of deposition which produces natural levees can also take place at the river mouth, building jetties of silt that protrude into open water. In the Mississippi delta distributary channels have prolonged their natural levees as silt jetties, extending into the lagoons which are a feature of this subsiding delta. The Mississippi carries an enormous load of sediment, and is able to build a delta projecting into the Gulf of Mexico in spite of the counteracting effects of marine waves and currents and the continuing subsidence of the land.

The relatively small rivers that drain into the Gippsland Lakes show similar features. The lower part of the Mitchell valley (Fig. 1) shows well-marked natural levees bordering the river channel. On the W. side these slope down into McLeod's Morass, a typical lateral depression, but on the E. side the valley floor opens on to Jones Bay, an arm of L. King. Under natural conditions McLeod's Morass was very often flooded by water overflowing from the river or carried in by tributary creeks, and although an outlet drain has been cut the area is still very wet in winter. Much of it is occupied by giant rush (*Juncus pallidus*) swamp vegetation. Below Eagle Point Bluff, a cliff of Tertiary sandstone and gravel, the river swings eastwards into L. King, the natural levees passing into silt jetties that protrude far out into the lake (Pl. VIII, fig. 1).

The Mitchell has a marked seasonal regime with a maximum in late winter (Table 1), and is subject to severe flooding after heavy rain. Flooding occurs frequently in the E. Gippsland valleys in the winter months, and in spring when rainfall is augmented by snow melt from the Eastern Highlands (Table 2). The construction of well-marked natural levees and of deltaic silt jetties is certainly assisted by repeated inundation of the valleys with silt-laden flood waters.

TABLE 1

River flow in the Mitchell at Bairnsdale—mean values 1890-1921 in '000 acre-feet
(State Rivers & Water Supply Commission River Gaugings)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Mean Total
29	18	19	19	33	79	89	102	127	96	43	31	685

TABLE 2

Flood-incidence in E. Gippsland, 1911-53
(East Gippsland Resources Survey, 1954)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
4	5	1	6	6	10	15	10	8	11	3	4	83

The extent to which the present valley floors occupy sites that were submerged by the Postglacial transgression is not easily determined. A few years ago the Country Roads Board made a series of borings across the valley floor of the Mitchell at Bairnsdale in search of suitable foundations for bridge construction, and their borings (Fig. 1, A-B) passed through river silt into underlying sand and gravel deposits which may well have accumulated at the head of a submerged gulf. Relics of a former lake-shore beach at the W. margin of the valley floor below Bairnsdale will be discussed more fully later. It appears that, at the maximum extent of submergence, L. King reached as far as Bairnsdale and that the lower part of the Mitchell valley floor has been formed by subsequent deposition. Supporting evidence comes from the pattern of river meanders, which are close and intricate above Bairnsdale but open, sweeping curves in the lower course. The same transition is seen in the Latrobe below Longford, the Thomson below Sale, the Avon below Redbank and the Tambo below Swan Reach, and in each case it is likely that the more gradual meanders mark the section of the valley floor formed by deposition in an area that was once submerged, while intricate meandering signifies subaerial conditions uninterrupted by submergence. The author has observed similar features elsewhere, notably in the rivers of Sussex (England), where intricate meanders give place downstream to open meanders at the point where the graded profile of stream erosion disappears beneath almost flat alluvial flood plains in sections that were submerged by the Postglacial transgression. The deltaic sections of the E. Gippsland valley floors are thus more extensive than the deltas which actually protrude from the present lake shores, and the lateral depressions are essentially infilled arms of the lake adjacent to silt jetties that were first prolonged, then built up as natural levees by deposition. It is remarkable that these relatively small rivers have been able to build deltas that protrude into the lakes, and the circumstances in which they have done so require careful analysis.

The Latrobe Delta

The Latrobe delta (Fig. 2) is a cuspate delta at the SW. corner of L. Wellington, built into a part of the lake that is sheltered from the prevailing westerly winds, but open to the easterly winds that frequently occur. Low natural levees bordering the river culminate in silt jetties that protrude into the lake, and the delta is covered by dense swamp scrub vegetation, mainly swamp paper-bark (*Melaleuca ericifolia*), with a few red gums (*Eucalyptus tereticornis*) on the river banks. Extensive reed fen, dominated by the common reed (*Phragmites communis*) and need mace (*Typha angustifolia*), occupies the lateral depressions bordering the Latrobe levees below Sale, which are frequently flooded. At the mouth of the river and along adjacent parts of the shore of L. Wellington there is a reed fringe dominated by the common reed, which is spreading outwards into the lake (Pl. IX, fig. 2). River silt is trapped by the reeds and built on to the delta, which is growing by prolongation of the jetties at its mouth and by marginal accretion along the lake shore. The reeds extend into water about 4 ft deep, but at their inner margin sedimentation has built up the land to a level at, or slightly above, average lake level, and here the reeds give place to swamp scrub dominated by *Melaleuca ericifolia*. The scrub is actually invading the back of the reed fringe, and as it takes over its shallow interlacing root network binds the soft lacustrine sediments. On the surface a mass of twigs, leaves and decaying bark forms brushwood peat, but just underneath this is silty material containing fragments of *Phragmites* straw, a relic of the reed community now replaced by scrub. A foot or so below this there is often a very soft wet blue or black organic material, so weak that the surface raft of brushwood peat and scrub will often quake under the weight of a man. This vegetation zonation on the delta indicates an ecological succession that brings about the encroachment of swamp land along the lake shore. It is comparable with the encroachment succession from reed fen to alder-sallow carr, the swamp woodland that develops around the Norfolk Broads, in eastern England.

The A'von Delta

This is very similar to the Latrobe delta, but rather smaller. The Avon, joined in its lower reaches by the Perry, flows into the NW. corner of L. Wellington

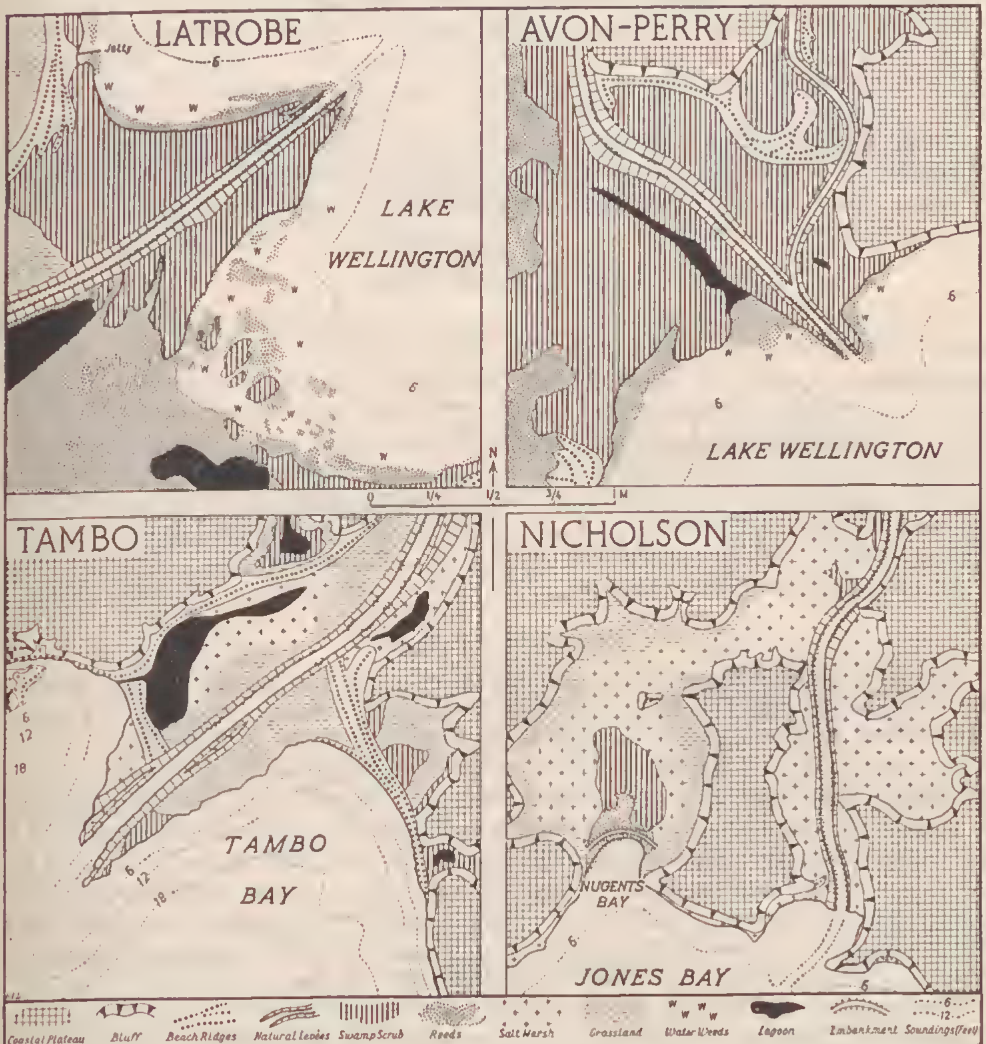

Fig. 2—The physiography and vegetation of the deltas of the Latrobe, Avon-Perry, Tambo and Nicholson R.

by way of a cuspate delta. Reeds borders the delta, and the succession to swamp scrub brings about encroachment at the mouth of the river and along the adjacent lake shores. At an early stage in the growth of this delta a sandspit was enclosed, and this can still be traced in the swamp land at the mouth of the Perry valley. *Phragmites* fen occupies the lateral depressions farther upstream.

The Tambo Delta

The Tambo delta in the NE. corner of L. King is similar in form to the Latrobe delta. A cuspate delta has been built into the lake, outflanking and enclosing beach ridges. The natural levees which border the river slope away into lateral depressions occupied by shallow lagoons which dry out in summer, and by salt marshes; the *Phragmites* fen is not present here, or along the lake shore, but a sparse reed growth borders the river channel farther upstream. In the absence of a shoreline reed fringe there is severe wave-erosion of the delta margins. Their outline has become irregular, and a line of dead red gums standing in the lake mark their former extent (Pl. IX, fig. 1). The W. jetty has been cut back farther than the E., being more exposed to waves generated by the prevailing westerly winds. Swamp scrub probably covered this delta under natural conditions, but most of it has been cleared and converted to pastureland, and it is reclaimed pastureland which is suffering erosion.

The Nicholson Delta

The Nicholson, the smallest of the 5 main rivers that flow into the Gippsland Lakes, has not built a delta comparable with the others. At one time the river probably flowed out into Nugents Bay, but during the later stages of the Post-glacial submergence it breached a narrow interfluve and flowed out into an arm of the lake formed by the drowning of an adjacent valley system. Salt marshes and *Melaleuca ericifolia* swamp scrub land now occupy these former embayments. *Phragmites* grows on an artificial bank built along the shore of L. King at Nugents Bay, and also on the river banks, but it is not present on the lake shore or around the river mouth. Wave erosion has cut out an embayment here, but the underwater topography suggests that a delta formerly protruded into the lake (Fig. 2).

The Mitchell Delta

The long digitate delta that winds into the N. part of L. King consists of silt jetties bordering the Mitchell R. (Pl. VIII, fig. 1). Its vegetation cover at the present time consists largely of pastureland, with patches of *Melaleuca ericifolia* swamp scrub and salt marsh, and *Phragmites* is confined to the E. end, except for a sparse growth along the river channel and at two or three places on the N. shore. Wave erosion is cutting back the margins of this delta (Pl. VIII, fig. 2), and salt marsh plants are invading pastureland on sites that are frequently splashed or sprayed by water from the lake. In 1919 a breach was made by the river just below Eagle Point during a severe flood (The Cut, Fig. 3), and more recently wave erosion has dissected the E. part of the delta into small islands. If present trends continue the Mitchell delta will wither and vanish during the next few decades.

The problem of the origin of these remarkable silt jetties has prompted several hypotheses. When the surveyors A. J. Skene and R. B. Smyth voyaged through the Gippsland Lakes in 1874, they saw the delta and suggested that it had grown from the vicinity of Bairnsdale southwards to the bluff at Eagle Point and thence eastwards into L. King. In this way the Mitchell had achieved the reclamation of a considerable portion of L. King (Skene and Smyth 1874). A few years later, the geologist A. W. Howitt published an account of the area in which he described the silt jetties as well-timbered, reed-fringed features, and interpreted them as a tongue of lacustrine sediment along which the Mitchell had maintained a channel by means of the 'ploughing action of floods' (Howitt 1879). The mechanism is obscure, and the jetties are almost certainly constructional forms prolonged by

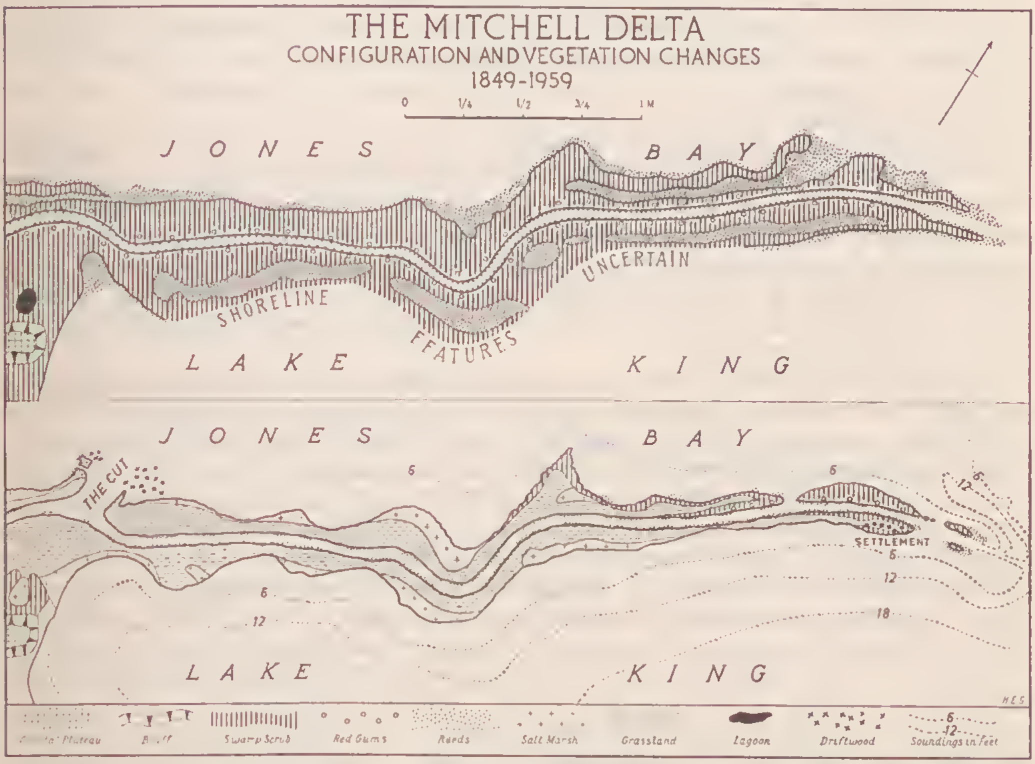

Fig. 3—The Mitchell delta as it was in 1849 (above) and as it was in 1959 (below).

deposition of silt at an advancing river mouth. J. W. Gregory (1903) took this view, pointing to the shoals, snags (dead trees and driftwood washed downstream) and patches of reeds beyond the river mouth as evidence of the future line of growth. At this time the delta had almost reached the farther shore of L. King and there was speculation as to whether it would impinge on that shore and deflect southwards or whether the outflow from Jones Bay, fed by the Nicholson R. would deflect it southwards before it reached the farther shore. This was never settled, for in the early years of the present century growth came to an end and in the last 40 years there has been considerable erosion.

Another hypothesis, put forward by H. T. Clifford (1949), was that the N. part of L. King was a submerged valley plain, and that the natural levees of the Mitchell remained partly exposed above sea level as silt jetties. When the valley below Bairnsdale is flooded the river-bed levees look much like silt jetties protruding into the lake, but the difficulty with this hyopthesis is the existence of a former lake-shore beach in the W. side of McLeod's Morass. This is a bank of sand and shingle at the foot of the valley-side bluff, extending as a barrier across the mouths of tributary valleys and protruding into the swamps at the N. end as a spit (Fig. 1). It consists of material that is very similar to the sand and shingle beaches found around the shores of L. King and L. Victoria and different from the silt which forms the natural levees of the Mitchell which stand between it and the present lake shore. At one stage, therefore, the lake extended to the bluffs on the W. side of the lower Mitchell valley. The Mitchell delta must have grown southwards from Bairnsdale across an embayment, much in the way that Skene and Smyth suggested, so that the silt jetties cannot have originated in the way described by Clifford.

It is remarkable that the silt jetties have grown so far without the breaching (crevassing) and branching that takes place along the jetties built by Mississippi distributaries, and it is clear that reed vegetation played a vital part in their evolution, the pattern of the reed community spreading into the lake each year and outlining the area in which sediment brought downstream during floods was trapped and consolidated. At present, in the absence of a reed fringe, the delta is being consumed by erosion, but there is considerable evidence that *Phragmites* formerly grew abundantly hereabouts.

The clearest evidence comes from the field notebooks and maps (inspected by courtesy of the Lands Department, Melbourne) which were compiled by John Wilkinson, who surveyed the country N. of L. King in 1849. These show the N. jetty covered with 'high reeds and scrub' and a lake shore fringed by 'very wet morass'. Examination of lake-floor mud just off the eroded N. shore of the delta led to discovery of root material and dead stems of *Phragmites*, and this suggests that the 'very wet morass' consisted of reeds spreading into the lake. The 1849 map show similar morass on the NW. fringes of Jones Bay, where reed growth persists. Fig. 3 includes a map of the probable form of the delta in 1849, based on evidence from Wilkinson's maps and notebooks. Howitt's description, already quoted, and Gregory's account suggest that this form persisted until the turn of the century, but since then the reed fringe has almost entirely disappeared, and erosion has developed; in 1959 (Fig. 3) the delta was clearly in course of decay. At one point the S. jetty was scarcely wider than the track which leads to the fishermen's settlement at the E. end, and a break-through here was imminent.

Large quantities of sediment are still carried down by the Mitchell, particularly during floods, but much of it goes out through The Cut into Jones Bay. It is significant that, in the absence of a reed fringe to trap the sediment, there is very little in the way of silt jetty formation here. Most of the sediment is carried out into Jones Bay and deposited on the lake floor. The growth of silt jetties therefore depended upon the presence of *Phragmites* around the river mouth and along the lake shores, trapping sediment and shaping the form of the delta. The digitate form must be attributed to the fact that the NW. corner of L. King is very well sheltered from both westerly and easterly winds; the cuspate deltas of the Latrobe, Avon and Tambo have grown in face of rather stronger wind-generated waves. It is very likely that the Tambo delta also formed in the presence of a reed fringe, and that the continued growth of the Latrobe and Avon deltas depends on the persistence of a reed fringe along their shores.

Reed Growth in the Gippsland Lakes

In a recent paper the author analysed the distribution of shoreline reed growth around the Gippsland Lakes at the present time in comparison with evidence of its former extent (Bird 1961). It was found that reed growth has been considerably reduced in the last 40 years, and the most likely explanation of this is an increase in the salinity of the lake water to levels above the salinity tolerance of *Phragmites communis;* none of the other possible explanations considered fitted the facts as well. Surveys carried out by the State Rivers and Water Supply Commission showed that the pattern of salinity in the Gippsland Lakes is determined largely by the influx of fresh water from the rivers and the influx of sea water through the artificial opening at Lakes Entrance, cut in 1889. The salinity regime is seasonal. In late winter, particularly after serious river flooding, the lakes are almost fresh but at the end of a dry summer they are brackish, and even in L. Wellington, the lake that lies farthest from the artificial entrance, salinity attains level between a quarter and a third of the salinity of Bass Strait (about 35‰ NaCl). Reed growth survives in L. Wellington, and in certain sites remote from the artificial entrance, particularly near the mouths of fresh-water creeks. It follows that the lake water has become too saline for *Phragmites* growth around much of the shore of L. King, and certainly on the shores of the Mitchell and Tambo deltas. The invasion of splashed pastureland by salt marsh plants is another indication of high salinity.

This change in the salinity regime of the lakes is almost certainly a consequence of the opening of the artificial entrance, which permitted much freer influx of sea water to the lakes than could have taken place formerly. Under natural conditions, prior to 1889, a pre-existing natural outlet from the lakes E. of Lakes Entrance township was frequently sealed off by a sand barrier in the summer months, and this would have excluded sea water at the season when it now enters very freely. Die-back of *Phragmites* has revealed that an intimate balance existed between sedimentation and ecological conditions; if a reed-fringe had not existed, river deltas of the type now seen could not have developed and a very much larger proportion of silt brought down by the rivers would have been carried out into the lakes and deposited in deeper water.

Conclusion

As a rule the formation of river deltas is simply due to the accumulation of superabundant sediment at river mouths, but in the Gippsland Lakes this accumulation depends on the presence of a reed fringe. The river deltas of the Gippsland Lakes thus offer a remarkable instance of the physiographic significance of ecological conditions. It is well known that vegetation can bring about modifications in physiographic development; a vegetation cover can stabilize blowing sand in fixed dune forms and a change in vegetation can lead to accelerated erosion on slopes. Reed growth can promote swamp encroachment on the shores of lakes and estuaries and halophytic vegetation can aid the build-up of salt marshes. The instance of reed growth playing a vital role in the growth of river deltas, to the extent that in its absence they would not exist, is probably rare. Such features are inevitably sensitive to changing ecological conditions, a point that is well illustrated by the present condition of deltas formerly built by the Mitchell, the Nicholson, and the Tambo. Their persistence or revival could take place only if the lakes became freshened so that *Phragmites* could spread to its former extent and resume its former role, or if some salt-tolerant shoreline reed, possibly one of the species of *Spartina,* invaded the lakes and took over the role formerly played by *Phragmites.*

Acknowledgements

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Explanation of Plates

Plate VIII

Fig. 1—The silt jetties of the Mitchell delta winding into L. King.
Fig. 2—The eroded southern shore of the Mitchell delta.

Plate IX

Fig. 1—The eroded delta at the mouth of the Tambo R.
Fig. 2—The reed-fringed delta at the mouth of the Latrobe R.